

What is claimed is:

1. A removable memory module for use with a hardened voyage recorder, said module comprising:

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(a) an outer housing including an inner cavity for containing a solid state memory;

(b) a cover for said outer housing;

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(c) a thermal insulator located within said inner cavity defining at least a portion of a second interior cavity, with said solid state memory being located within said second inner cavity; and

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(d) a boiler located within said second interior cavity including a containment compartment for containing a thermal mass, a protective compartment within which said solid state memory is located and means for interconnecting said containment compartment and said protective compartment, wherein said means for interconnecting, when open, provides a passageway between said containment compartment and said protective compartment, wherein said solid state memory is protected from temperatures on the order of 260°C for approximately ten hours.

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2. A module as set forth in claim 1 wherein solid state memory includes BGA memory.

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3. A module as set forth in claim 1 wherein said solid state memory is stacked memory.

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4. A module as set forth in claim 1 wherein said boiler includes a cover plate which covers said protective compartment, said cover plate defines a through hole spaced apart from its edge, and said solid state memory is coupled to a cable which extends through said through hole.

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5. A module as set forth in claim 4 wherein said through hole is substantially circular.

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6. A module as set forth in claim 4 wherein said cover plate is press fit to said boiler.

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7. A module as set forth in claim 1 wherein said thermal mass includes a phase change material (PCM).

8. A module as set forth in claim 7 wherein said PCM utilizes the energy absorption from vaporization to absorb heat.

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9. A module as set forth in claim 7 wherein said PCM is water.

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10. A module as set forth in claim 9 wherein said water is contained in a dry material which inhibits the water from freezing or expanding.

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11. A module as set forth in claim 10 wherein said dry material comprises sponge, silica, polyacrylamide, calcium silicate or pottery clay.

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12. A module as set forth in claim 7 wherein said thermal mass is a dry powder formed by combining water and silica.

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13. A module as set forth in claim 1 wherein said thermal mass absorbs shock.

14. A module as set forth in claim 13 wherein said thermal mass is a gel formed by combining water and polyacrylamide.

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15. A boiler as set forth in claim 1 further comprising a fusible valve that opens at a predetermined temperature to allow said thermal mass to flow through said passageway.

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16. A boiler as set forth in claim 15 wherein said fusible valve comprises at least one thermal vent plug which is released at a predetermined temperature.

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17. A boiler as set forth in claim 16 wherein said thermal vent plug comprises wax, paraffin, a bismuth alloy or electrical solder.

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18. A module as set forth in claim 1 wherein said cover for said outer housing is coupled to said outer housing with a snap ring.

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19. A module as set forth in claim 18 wherein said cover for said outer housing is coupled to said outer housing with two snap rings.

20. A module as set forth in claim 1 wherein said outer housing withstands a penetration of a 100mm 250kg  
5 projectile at three meters.

21. A module as set forth in claim 1 wherein said outer housing will withstand a 50g's, 11 ms half sine shock.

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22. A module as set forth in claim 1 wherein said outer housing will withstand an immersion of 6,000 meters depth.

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23. A removable memory module for use with a hardened voyage recorder, said module comprising:

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(a) an outer housing including an inner cavity for containing a solid state memory;

(b) a cover for said outer housing;

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(c) a thermal insulator located within said inner cavity defining at least a portion of a second interior cavity, with said solid state memory being located within said second inner cavity; and

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(d) a boiler located within said second interior cavity including a containment compartment for containing a thermal mass, a protective compartment within which said solid state memory is located and means for interconnecting said containment compartment and said protective compartment, wherein said means for interconnecting, when open, provides a passageway between said containment compartment and said protective compartment, wherein said solid state memory includes at least one BGA chip.

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24. A module as set forth in claim 23 wherein solid state memory includes a plurality of BGA memory chips.

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25. A module as set forth in claim 23 wherein said solid state memory is stacked memory.

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26. A module as set forth in claim 23, wherein said boiler includes a cover plate which covers said protective compartment, said cover plate defines a through hole spaced apart from its edge, and said solid state memory is coupled to a cable which extends through said through hole.

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27. A module as set forth in claim 26 wherein said through hole is substantially circular.

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28. A module as set forth in claim 26 wherein said cover plate is press fit to said boiler.

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29. A module as set forth in claim 23 wherein said thermal mass includes a phase change material (PCM).





36. A module as set forth in claim 35 wherein said thermal mass is a gel formed by combining water and polyacrylamide.

37. A boiler as set forth in claim 23 further comprising a fusible valve that opens at a predetermined temperature to allow said thermal mass to flow through said passageway.

38. A boiler as set forth in claim 37 wherein said fusible valve comprises at least one thermal vent plug which is released at a predetermined temperature.

39. A boiler as set forth in claim 38 wherein said thermal vent plug comprises wax, paraffin, a bismuth alloy or electrical solder.

40. A module as set forth in claim 23 wherein said cover for said outer housing is coupled to said outer housing with a snap ring.

41. A module as set forth in claim 40 wherein said cover  
for said outer housing is coupled to said outer housing  
5 with two snap rings.

42. A module as set forth in claim 23 wherein said outer housing withstands a penetration of a 100mm 250kg projectile at three meters.

43. A module as set forth in claim 23 wherein said outer housing will withstand a 50g's, 11 ms half sine shock.

45. A removable memory module for use with a hardened voyage recorder, said module comprising:

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(a) an outer housing including an inner cavity for containing a solid state memory;

(b) a cover for said outer housing;

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(c) a thermal insulator located within said inner cavity defining at least a portion of a second interior cavity, with said solid state memory being located within said second inner cavity; and

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(d) a boiler located within said second interior cavity including a containment compartment for containing a thermal mass, a protective compartment within which said solid state memory is located and means for interconnecting said containment compartment and said protective compartment, wherein said means for interconnecting, when open, provides a passageway between said containment compartment and said protective compartment, wherein said outer housing has an impact strength suitable for use in marine applications.

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46. A module as set forth in claim 45 wherein solid state memory includes BGA memory.

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47. A module as set forth in claim 45 wherein said solid state memory is stacked memory.

10 48. A module as set forth in claim 45 wherein said boiler includes a cover plate which covers said protective compartment, said cover plate defines a through hole spaced apart from its edge, and said solid state memory is coupled to a cable which extends through said through  
15 hole.

49. A module as set forth in claim 48 wherein said through hole is substantially circular.

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50. A module as set forth in claim 48 wherein said cover plate is press fit to said boiler.

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51. A module as set forth in claim 45 wherein said thermal mass includes a phase change material (PCM).



58. A module as set forth in claim 57 wherein said thermal mass is a gel formed by combining water and polyacrylamide.

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59. A boiler as set forth in claim 45 further comprising a fusible valve that opens at a predetermined temperature to allow said thermal mass to flow through said passageway.

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60. A boiler as set forth in claim 59 wherein said fusible valve comprises at least one thermal vent plug which is released at a predetermined temperature.

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61. A boiler as set forth in claim 60 wherein said thermal vent plug comprises wax, paraffin, a bismuth alloy or electrical solder.

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62. A module as set forth in claim 45 wherein said cover for said outer housing is coupled to said outer housing with a snap ring.

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63. A module as set forth in claim 62 wherein said cover for said outer housing is coupled to said outer housing with two snap rings.

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64. A module as set forth in claim 45 wherein said outer housing withstands a penetration of a 100mm 250kg projectile at three meters.

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65. A module as set forth in claim 45 wherein said outer housing will withstand a 50g's, 11 ms half sine shock.

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66. A module as set forth in claim 45 wherein said outer housing will withstand an immersion of 6,000 meters depth.

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67. A removable memory module for use with a hardened voyage recorder, said module comprising:

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(a) an outer housing including an inner cavity for containing a solid state memory;

(b) a cover for said outer housing;

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(c) a thermal insulator located within said inner cavity defining at least a portion of a second interior cavity, with said solid state memory being located within said second inner cavity; and

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(d) a boiler located within said second interior cavity including a containment compartment for containing a thermal mass, a protective compartment within which said solid state memory is located and means for interconnecting said containment compartment and said protective compartment, wherein said means for interconnecting, when open, provides a passageway between said containment compartment and said protective compartment, wherein wherein said boiler includes a cover plate which covers said protective compartment, said cover plate defines a through hole spaced apart

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from its edge, and said solid state memory is coupled to a cable which extends through said through hole.

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68. A module as set forth in claim 67 wherein solid state memory includes BGA memory.

10 69. A module as set forth in claim 67 wherein said solid state memory is stacked memory.

15 70. A module as set forth in claim 67 wherein said outer housing is capable of withstanding a marine crash environment.

20 71. A module as set forth in claim 67 wherein said through hole is substantially circular.

25 72. A module as set forth in claim 67 wherein said cover plate is press fit to said boiler.

73. A module as set forth in claim 67 wherein said thermal mass includes a phase change material (PCM).

74. A module as set forth in claim 73 wherein said PCM utilizes the energy absorption from vaporization to absorb heat.

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75. A module as set forth in claim 73 wherein said PCM is water.

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76. A module as set forth in claim 75 wherein said water is contained in a dry material which inhibits the water from freezing or expanding.

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77. A module as set forth in claim 76 wherein said dry material comprises sponge, silica, polyacrylamide, calcium silicate or pottery clay.

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78. A module as set forth in claim 67 wherein said thermal mass is a dry powder formed by combining water and silica.

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79. A module as set forth in claim 67 wherein said thermal mass absorbs shock.

80. A module as set forth in claim 71 wherein said thermal mass is a gel formed by combining water and polyacrylamide.

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81. A boiler as set forth in claim 67 further comprising a fusible valve that opens at a predetermined temperature to allow said thermal mass to flow through said passageway.

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82. A boiler as set forth in claim 81 wherein said fusible valve comprises at least one thermal vent plug which is released at a predetermined temperature.

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83. A boiler as set forth in claim 82 wherein said thermal vent plug comprises wax, paraffin, a bismuth alloy or electrical solder.

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84. A module as set forth in claim 67 wherein said cover for said outer housing is coupled to said outer housing with a snap ring.

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85. A module as set forth in claim 84 wherein said cover for said outer housing is coupled to said outer housing with two snap rings.

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86. A module as set forth in claim 67 wherein said outer housing withstands a penetration of a 100mm 250kg projectile at three meters.

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87. A module as set forth in claim 67 wherein said outer housing will withstand a 50g's, 11 ms half sine shock.

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88. A module as set forth in claim 67 wherein said outer housing will withstand an immersion of 6,000 meters depth.

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89. A hardened voyage recorder for use on a marine vessel, comprising:

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- (a) a first module including a mountable base mountable on the marine vessel and containing electronics for receiving data from data sensors located on the marine vessel and for writing data to a memory module;
- (b) a removable memory module removably coupled to said first module, said memory module including
  - (i) an outer housing including an inner

cavity for containing a solid state  
memory;

(ii) a cover for said outer housing;

(iii) a thermal insulator located within said  
inner cavity defining at least a portion  
of a second interior cavity, with said  
solid state memory being located within  
said second inner cavity; and

(iv) a boiler located within said second  
interior cavity including a containment  
compartment for containing a thermal  
mass, a protective compartment within  
which said solid state memory is located  
and means for interconnecting said  
containment compartment and said  
protective compartment, wherein said  
means for interconnecting, when open,  
provides a passageway between said  
containment compartment and said  
protective compartment.

90. The apparatus as set forth in claim 89 wherein solid  
state memory includes BGA memory.

91. The apparatus as set forth in claim 89 wherein said solid state memory is stacked memory.

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92. The apparatus as set forth in claim 89 wherein said boiler includes a cover plate which covers said protective compartment, said cover plate defines a through hole spaced apart from its edge, and said solid state memory is coupled to a cable which extends through said through hole.

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93. The apparatus as set forth in claim 92 wherein said through hole is substantially circular.

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94. The apparatus as set forth in claim 92 wherein said cover plate is press fit to said boiler.

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95. The apparatus as set forth in claim 89 wherein said thermal mass includes a phase change material (PCM).

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96. The apparatus as set forth in claim 95 wherein said PCM utilizes the energy absorption from vaporization to absorb heat.

97. The apparatus as set forth in claim 95 wherein said PCM is water.

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98. The apparatus as set forth in claim 97 wherein said water is contained in a dry material which inhibits the water from freezing or expanding.

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99. The apparatus as set forth in claim 98 wherein said dry material comprises sponge, silica, polyacrylamide, calcium silicate or pottery clay.

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100. The apparatus as set forth in claim 89 wherein said thermal mass is a dry powder formed by combining water and silica.

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101. The apparatus as set forth in claim 89 wherein said thermal mass absorbs shock.

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102. The apparatus as set forth in claim 101 wherein said thermal mass is a gel formed by combining water and polyacrylamide.

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103. A boiler as set forth in claim 89 further comprising  
a fusible valve that opens at a predetermined temperature  
5 to allow said thermal mass to flow through said  
passageway.

104. A boiler as set forth in claim 103 wherein said  
10 fusible valve comprises at least one thermal vent plug  
which is released at a predetermined temperature.

105. A boiler as set forth in claim 104 wherein said  
15 thermal vent plug comprises wax, paraffin, a bismuth  
alloy or electrical solder.

106. The apparatus as set forth in claim 99 wherein said  
20 cover for said outer housing is coupled to said outer  
housing with a snap ring.

107. The apparatus as set forth in claim 106 wherein said  
25 cover for said outer housing is coupled to said outer  
housing with two snap rings.



108. The apparatus as set forth in claim 89 wherein said  
outer housing withstands a penetration of a 100mm 250kg  
5 projectile at three meters.

109. The apparatus as set forth in claim 89 wherein said  
outer housing will withstand a 50g's, 11 ms half sine  
10 shock.

110. The apparatus as set forth in claim 89 wherein said  
outer housing will withstand an immersion of 6,000 meters  
15 depth.

111. The apparatus as set forth in claim 89 wherein said  
solid state memory is protected from temperatures on the  
20 order of 260°C for approximately ten hours

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112. A process for fabricating a removable memory module  
for a hardened voyage recorder, comprising the steps of:

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(a) fabricating a boiler that includes a  
containment compartment for storing a thermal  
mass and a separate protective compartment for  
housing an electronic memory device to be  
protected from heat, moisture and shock;

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(b) filling said containment compartment with a  
thermal mass;

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(c) placing said electronic memory device in said  
protective compartment;

(d) housing said boiler in a covered outer housing  
that includes, within said covered outer  
housing, a thermal insulator defining a cavity  
within which to situate and protect said  
boiler; and

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(e) providing a cable passageway formed in said  
thermal insulator, said cable passageway  
extending to and thru said covered outer  
housing; such that said electronic memory  
device is protected from the environment of a  
marine crash.

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113. A process as set forth in claim 112 wherein said  
electronic memory is protected from temperatures on the  
5 order of 260°C for approximately ten hours.

114. A process as set forth in claim 112 wherein said  
electronic memory includes BGA memory.

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115. A process as set forth in claim 112 wherein said  
boiler includes a cover plate which covers said  
protective compartment, said cover plate defines a  
15 through hole spaced apart from its edge, and said solid  
state memory is coupled to a cable which extends through  
said through hole.

20 116. A process as set forth in claim 115 wherein said  
cover plate is press fit to said boiler.

117. A process as set forth in claim 112 wherein said  
25 outer housing withstands a penetration of a 100mm 250kg  
projectile at three meters.

118. A process as set forth in claim 112 wherein said outer housing will withstand a 50g's, 11 ms half sine shock.

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119. A process as set forth in claim 112 wherein said outer housing will withstand an immersion of 6,000 meters depth.

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120. A boiler for protecting a memory module located within a hardened voyage recorder from low temperature fires, comprising:

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(a) a containment compartment for containing a thermal mass;

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(b) a protective compartment within which said memory module is located; and

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(c) means for interconnecting said containment compartment and said protective compartment, wherein said means for interconnecting, when open, provides a passageway for said thermal mass to flow between said containment compartment and said protective compartment and protect said memory module from temperatures on the order of 260°C for approximately ten hours.

121. A boiler as set forth in claim 120 wherein memory module includes solid state BGA memory.

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122. A boiler as set forth in claim 120 wherein said memory module is stacked memory.

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123. A boiler as set forth in claim 120 wherein said boiler further includes a cover plate which covers said protective compartment.

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124. A boiler as set forth in claim 123 wherein said cover plate is press fit to said boiler.

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125. A boiler as set forth in claim 120 wherein said thermal mass includes a phase change material (PCM).

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126. A boiler as set forth in claim 125 wherein said PCM utilizes the energy absorption from vaporization to absorb heat.

127. A boiler as set forth in claim 125 wherein said PCM is water.

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128. A boiler as set forth in claim 127 wherein said water is contained in a dry material which inhibits the water from freezing or expanding.

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129. A boiler as set forth in claim 128 wherein said dry material comprises sponge, silica, polyacrylamide, calcium silicate or pottery clay.

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130. A boiler as set forth in claim 125 wherein said thermal mass is a dry powder formed by combining water and silica.

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131. A boiler as set forth in claim 120 wherein said thermal mass absorbs shock.

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132. A boiler as set forth in claim 131 wherein said thermal mass is a gel formed by combining water and polyacrylamide.

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133. A boiler as set forth in claim 120 further comprising a fusible valve that opens at a predetermined temperature to allow said thermal mass to flow through said passageway.

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134. A boiler as set forth in claim 133 wherein said fusible valve comprises at least one thermal vent plug which is released at a predetermined temperature.

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135. A boiler as set forth in claim 134 wherein said thermal vent plug comprises wax, paraffin, a bismuth alloy or electrical solder.

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136. A boiler for protecting a memory module located within a hardened voyage recorder from low temperature fires, comprising:

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(a) a containment compartment for containing a thermal mass;

(b) a protective compartment within which said memory module is located; and

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(c) means for interconnecting said containment compartment and said protective compartment, wherein said means for interconnecting, when

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open, provides a passageway for said thermal mass to flow between said containment compartment, wherein said boiler includes a cover plate which covers said protective compartment, said cover plate defining a through hole spaced apart from its edge, and said memory module is coupled to a cable which extends through said through hole.

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137. A process for fabricating a boiler used to contain and protect a removable memory module for a hardened voyage recorder, comprising the steps of:

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- (a) fabricating a containment compartment for storing a thermal mass;
- (b) fabricating a separate protective compartment for housing an electronic memory device to be protected from heat, moisture and shock;
- (c) filling said containment compartment with a thermal mass;
- (d) placing said electronic memory device in said protective compartment;
- (d) covering said protective compartment with

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a cover plate including a through hole spaced  
apart from its edge; and

(e) coupling said memory module to a cable which  
extends through said through hole.

138. A method as set forth in claim 137 further  
comprising the step of utilizing a press fit cover to  
cover said protective compartment.

139. A method as set forth in claim 137 further  
comprising the step of interconnecting said containment  
compartment and said protective compartment with means  
that when open provides a passageway for said thermal  
mass to flow between said containment compartment and  
said protective compartment.

140. A method as set forth in claim 137 wherein said  
process is utilized to fabricate a boiler that is able to  
protect said memory module from temperatures on  
the order of 260°C for approximately ten hours.

141. A method as set forth in claim 137 wherein said  
thermal mass is a phase change material.